AD-A159 421 SUBMICRON PHONICS I(U) GRAZ UNIV (AUSTRIA) THEORETICAL PHYSICS INST 22 MAR 85 DAJA45-84-M-0394 1/1

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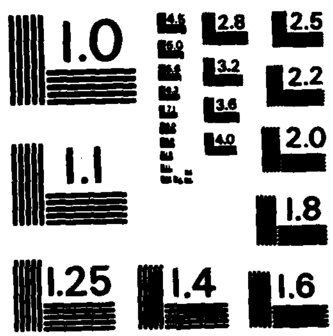


MICROCOPY RESOLUTION TEST CHART

KARL-FRANZENS-UNIVERSITÄT GRAZ
INSTITUT FÜR THEORETISCHE PHYSIK
A-8010 Graz, Universitätsplatz 5
Austria
Prof.Dr.Peter Kocevar

Graz, den March 22nd, 1985
Telefon (0316) 380-52 25
Telex 31662

US-Army RDSG (UK)
c/o Lt. Col.James F.Harvey
"Edison House" 233 Old Marylebone Rd.
London NW1 5TH
England

Concerns: Contract DAJA45-84-M-0394
Project "Submicron Phononics I"

Second Interim Report (Dec.1984-March 1985)

Scope of Project: Theoretical prediction of the speed of Gallium-Arsenide submicron-devices by considering for the first time possible effects of phonon disturbances on the electron-mobility.

Research Progress: time-dependent FORTRAN-code and preliminary results

The displaced maxwellian model for hot electrons in the central valley of polar semiconductors was extended to include the detailed time-dependence of longitudinal optical (LO) phonon amplification in n-GaAs at room-temperature in the velocity-overshoot regime. Assuming a practically instantaneous adaption of the electrons to the LO-phonon built-up, which in turn is calculated from the time-dependent Phonon-Boltzmann-equation, the FORTRAN-code for spatially homogeneous transport was developed ~~(see Appendix)~~ and put to a first use.

Noticeable modifications of the mobility were found during the first few picoseconds after the onset of a high field pulse. This effect results from mutual drag and heating between the coupled systems of carriers and LO-phonons. The additional cor-

relation of the strongly energy-dependent momentum-losses of the electrons to ionized donors and of the reduced cooling efficiency of the amplified LO-phonons for the carriers seems to play a secondary role. To get a better insight into these different mechanisms, the possibility of setting up a simple, (hopefully) analytical model of the carrier-phonon-impurity dynamics is being explored.

For the case of dominant drag of carriers by the nonequilibrium phonons the full numerical analysis predicts pronounced increases of the intravalley mobility within a few picoseconds. For fields higher than typically 2000V/cm, the carrier-phonon system evolves towards an instability: after a few picoseconds a critical mean-carrier drift-velocity of typically 4.10^7cm/s is reached, beyond which no solution of the instantaneous energy-momentum balance of the carriers exists. This critical behaviour indicates the breakdown of the spatial homogeneity underlying the model, similar to the usual interpretation of S- or N-shaped current-voltage characteristics. These nonequilibrium phonon effects will interfere with and will most probably be overridden by the Gunn-effect, because both mechanisms are effectuated on a picosecond time scale. This possibility is presently investigated through an extension of the model to the many-valley case.

The results reported above are still preliminary, as the numerical stability of the procedure will have to be closely analysed. But a strong indication of their physical relevance seems to come from the similar finding of nonequilibrium-acoustic-phonon-induced increases of steady state mobilities for low-temperature transport in previous theoretical models of acousto-electric phenomena.

For the next phase of the research project we foresee a detailed exchange of ideas with Dr.H.Grubin about his preferred choices of material parameters, about the influence of external circuits to the time-dependent current-voltage characteristics, and about the most efficient way to implement the Graz-code

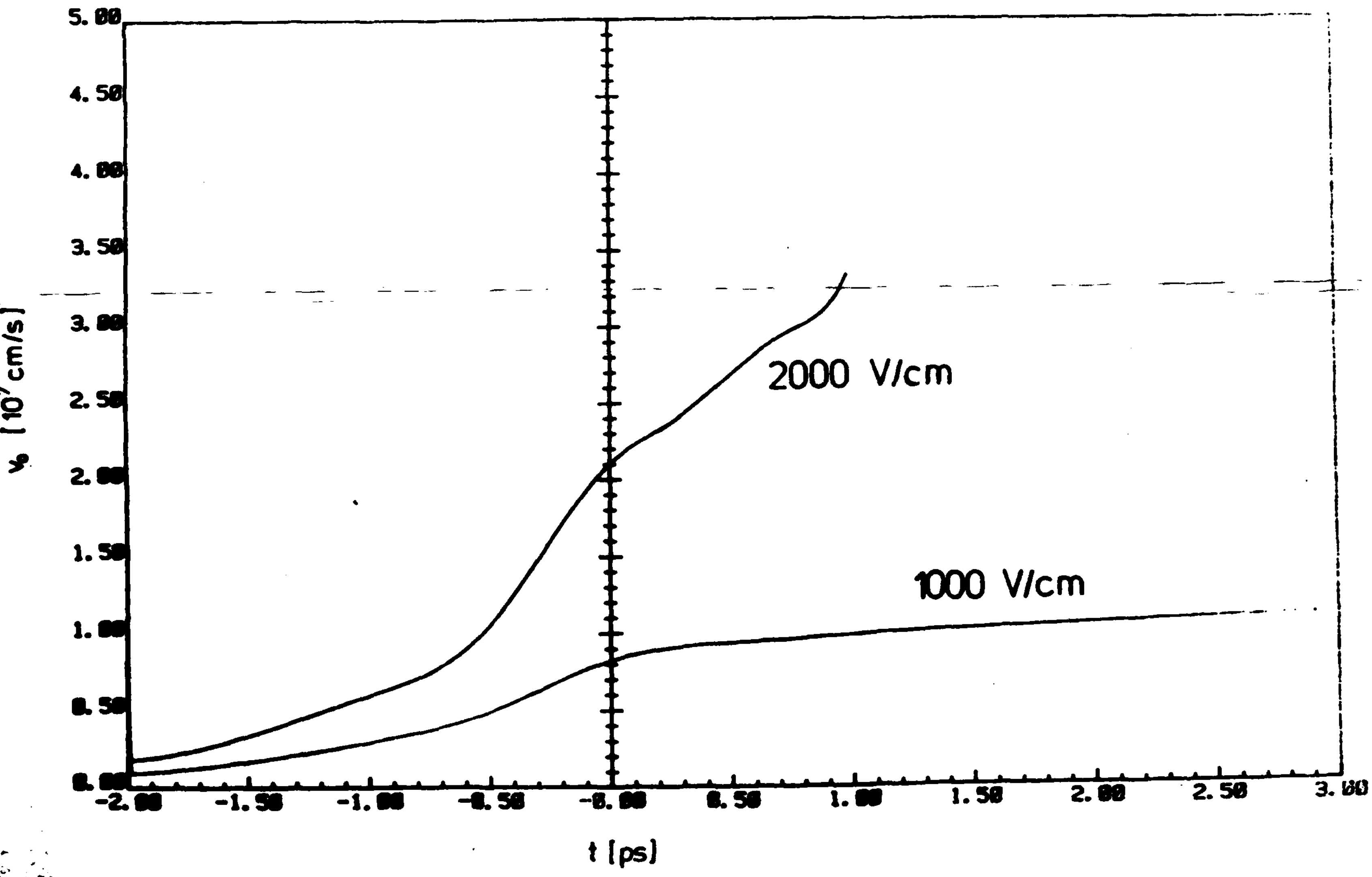
into Dr.Grubin's code for spatial inhomogeneity, most probably by way of using appropriate slab configurations.

For this reason a visit of Dr.Grubin to Graz within the next few months would be of great importance for the present project.

The following appendix shows the flow charts for the numerical code and preliminary results for the mean electron-drift velocity v_0 as function of time for field pulses of 1000 and 2000 V/cm with an exponential rise-time of 1ps.

P. Kocevar

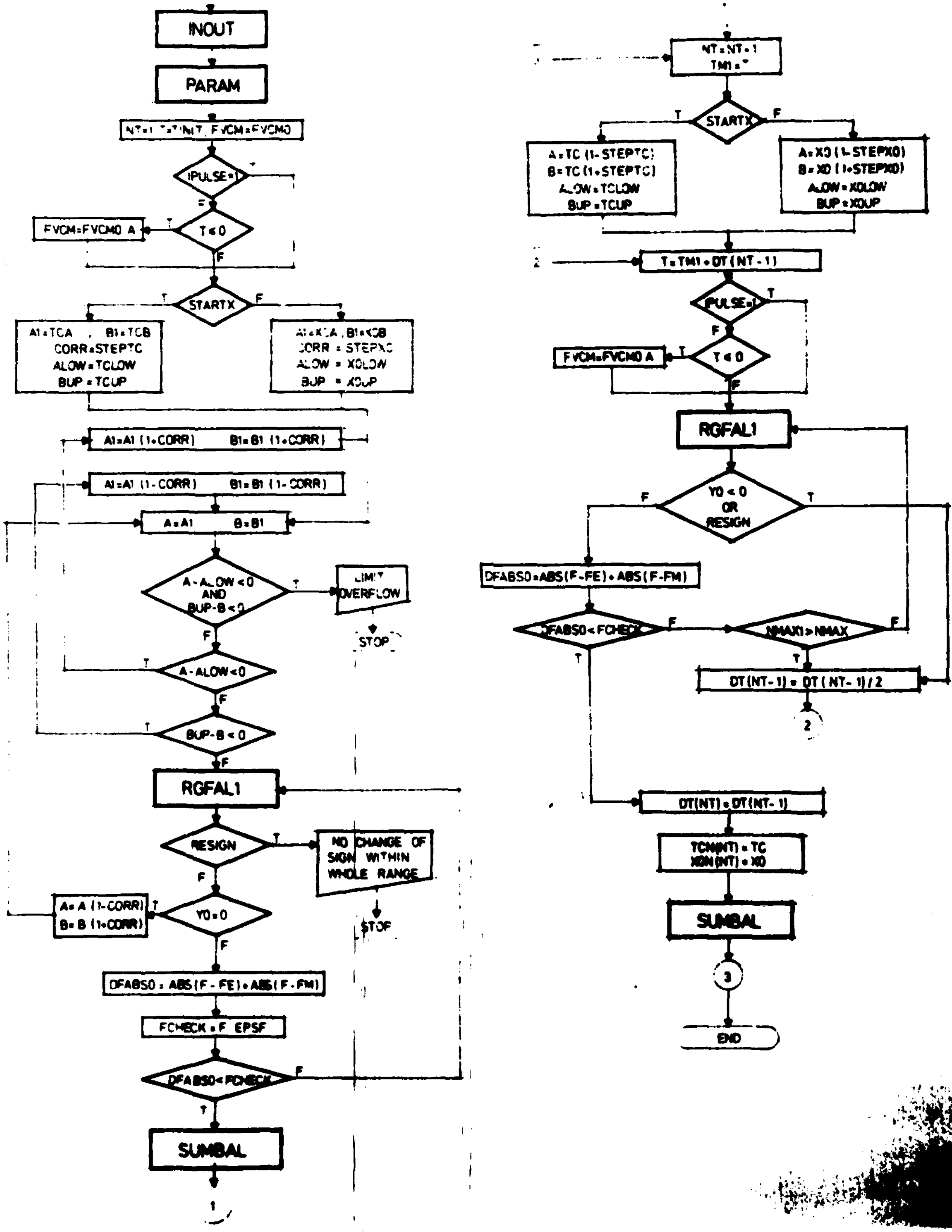
FIGURE 1



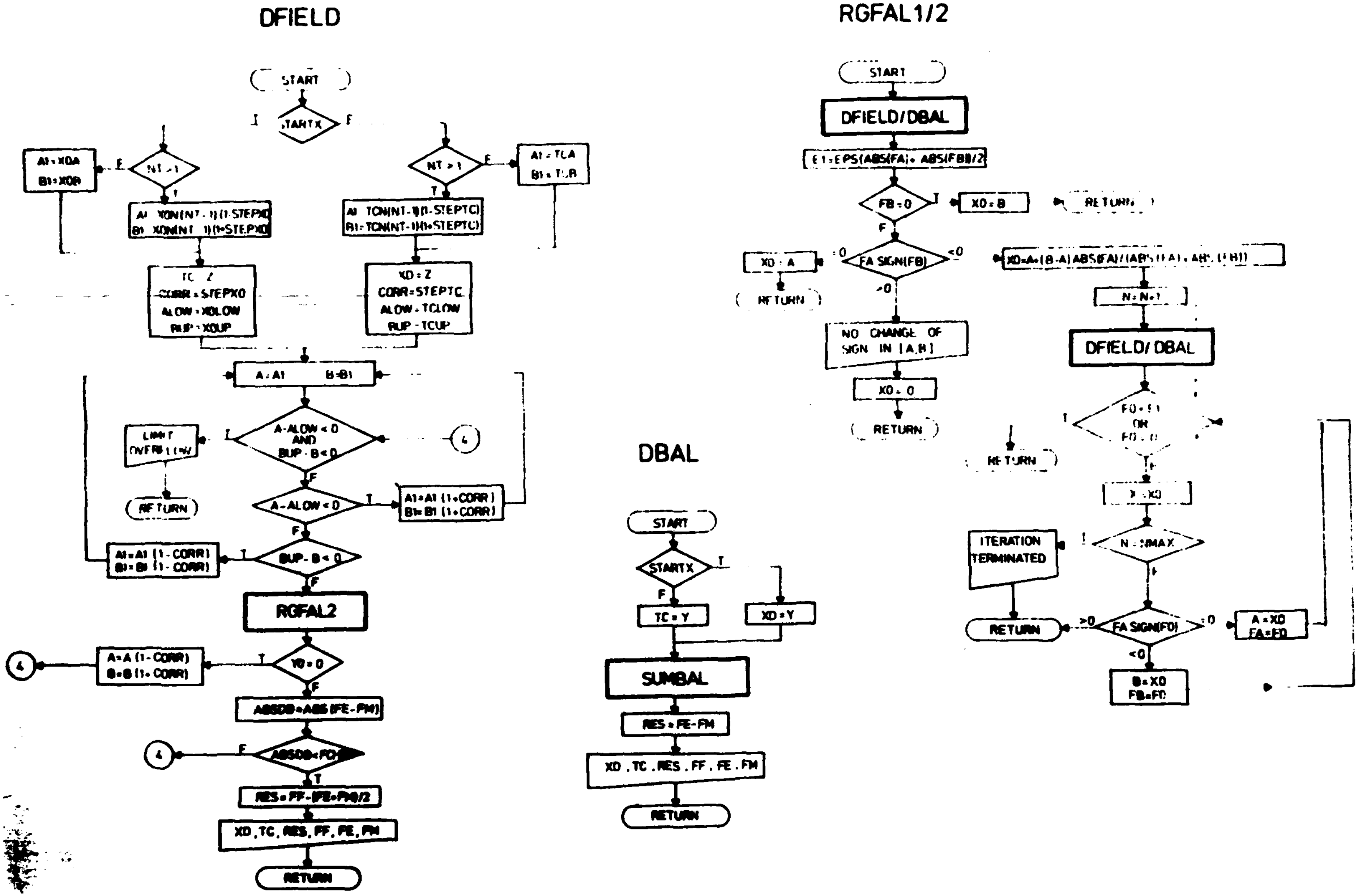
2000 V/cm
1000 V/cm
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-2.00
-1.50
-1.00
-0.50
-0.00
0.50
1.00
1.50
2.00
2.50
3.00
v_d [10^7 cm/s]
t [ps]

FLOW-CHART

MAIN PROGRAM

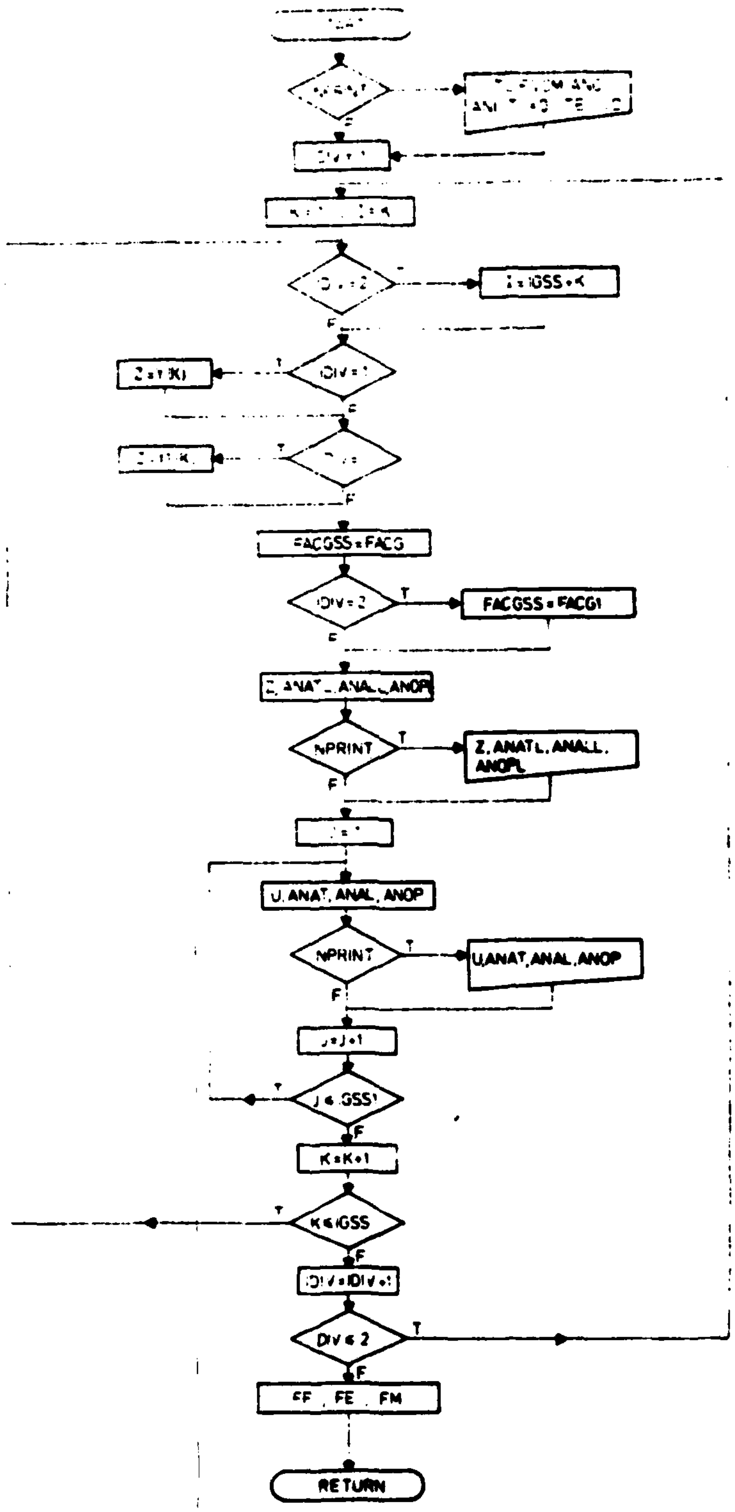


FLOW-CHART


DFIELD
START
STARTX
NT > 1
A1 = XOA
B1 = XOB
A1 = TCA
B1 = TCB
TC = Z
CORR = STEPXO
ALOW = XOLOW
BUP = XOUP
XD = Z
CORR = STEPTC
ALOW = TCLOW
BUP = TCUP
A = A1 B = B1
A-ALOW < 0 AND BUP - B < 0
RETURN
A-ALOW < 0
A1 = A1 (1+CORR)
B1 = B1 (1+CORR)
BUP - B < 0
A1 = A1 (1 - CORR)
B1 = B1 (1 - CORR)
RGFAL2
YD = 0
A = A (1 - CORR)
B = B (1 + CORR)
RETURN
DBAL
START
STARTX
TC = Y
XD = Y
SUMBAL
RES = FE - FM
XD, TC, RES, FF, FE, FM
RETURN
RGFAL1/2
START
DFIELD/DBAL
FB = 0
XO = B
RETURN
FA SIGN(FB)
XO = A
RETURN
NO CHANGE OF SIGN IN [A,B]
XO = 0
RETURN
N = N+1
DFIELD/DBAL
RETURN
ITERATION TERMINATED
RETURN
FA SIGN(FO)
A = XO
FA = FO
B = XO
FB = FO

FLOW-CHART

SUMBAL



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